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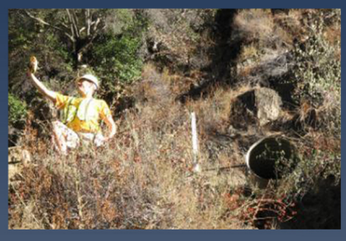



Reconnaissance Fish Passage Assessment Intructions and Procedures

Caltrans

March 31, 2007

HDR

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CALTRANS

Reconnaissance Fish Passage Assessment Instructions and Procedures

Contract No. 43A0150
Task Order 3

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Prepared for:

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Division of Environmental Analysis
Office of Biology and Technical Assistance
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For individuals with sensory disabilities this document is available in alternate formats. Please call or write Richard Hill, Caltrans Task Order Manager, at P.O. Box, 942784, Sacramento, CA 04274-001. 916-653-8117 Voice, or use the CA Relay Service TTY number 1-800-735-2929.

Table of Contents

Introduction

The purpose of this document is to provide direction on how to conduct Reconnaissance Assessment evaluations of State Highway System road-stream crossings using the Caltrans Fish Passage Survey protocols. The document includes a description of the general approach to conducting the surveys, specific directions and guidance on completing the survey forms, equipment needs, and brief descriptions and definitions of concepts and terms routinely used in evaluating stream attributes, stream crossing facilities and other parameters used to evaluate fish passage conditions.

The document provides survey personnel a basic understanding and specific guidance related to conducting reconnaissance fish passage surveys. Reconnaissance surveys include both office and field data collection. Data acquired per reconnaissance surveys are considered the most suitable for describing stream crossing sites and related fish passage issues without accessing areas outside the Caltrans right of way. Permission to access properties adjacent to the Caltrans right of way is typically required when collecting channel morphology data to evaluate fish passage.

This protocol was developed to make sure that all field crews provide complete, accurate, and consistent information for Caltrans' Fish Passage and Culvert Identification Programs. A section on definitions and standard terminology is included to further help maintain consistency in the use of terms and concepts and assist survey personnel better understand technical details associated with the survey of fish passage sites.

Part A. Approach to Reconnaissance Fish Passage Assessment

This section provides a discussion of the questions and decisions commonly confronted when performing fish passage surveys.

What to Survey

Nearly all waterways, drainages, and water conveyance passing under a State Highway System facility will be located and surveyed to identify the site, type of facility and whether it requires more in-depth surveys.

Pre-field Survey

Information and activities required before the survey crews enter the field include:

- Coordination with Caltrans district personnel, including maintenance and environmental staff contacts,
- Identification of survey locations,

- Inventory and check of required equipment and supplies,

- Copies of the Caltrans culvert log, bridge log, postmile log, if available for the survey area, USGS 7.5 minute maps, and prioritized watershed site location maps (Caltrans 2006 in prep), this protocol document, contact information, and

- Acquisition and entry of all survey information that is to be obtained outside of the field.

Some specific requirements follow:

- Acquire and enter information on Land ownership, historical fish distribution, fisheries information and hydrology information for the stream/site(s) to be surveyed. Much of the information is available in the Caltrans Survey Priority Report (Caltrans 2007).

- Itinerary should be prepared for each survey period (bimonthly) to assure survey personnel, logistic support, and consistency of survey effort with survey program objectives is being accomplished. Itinerary should be prepared by field lead and field coordinator(s).

- Contact appropriate maintenance and environmental staff in the District(s) as early as possible to inform them of the dates and locations (Counties, highways, etc.) of the surveys. This should be done by the field coordinator and verified by the field team leader. A follow up message should be provided to the same District staff within a week of the actual survey.

- Maps
  - USGS 7.5 minute map of survey area
  - Watershed map from Caltrans Survey Priority Project (may be in both hardcopy and electronic format)

- Contact Lists
  - List of contacts in District including "Emergency" maintenance contact
  - List of local emergency care facilities and agencies
  - Field Coordinator

- Documents
  - Caltrans Survey Priority report – This report contains a list of survey sites
  - Property access permission (Required for Detailed Fish Passage Assessment surveys)
  - Protocol - This document
  - District Culvert log (not all culverts are listed in the culvert log)
  - District Bridge log
  - District Postmile log (not all Districts have a postmile log)

Caltrans Task Order or other documents to identify the survey personnel as agents of Caltrans when accessing Caltrans Right of Way.
Field Survey Forms

- Equipment check (per Appendix A)

General Approach

The surveys are intended to locate all road-waterway crossings and assess fish passage conditions where state highway system facilities cross anadromous salmonid streams. If the site crosses a drain, rather than a natural stream, or if it is on a non-fish-producing stream, only location information should be collected. If the site is on a viable fish-bearing stream and has potential fish passage constraints, a detailed, Detailed Fish Passage Assessment survey should be completed. Similarly, if the site is a bridge without obvious constraints to fish passage, as defined below, it is does not require a detailed survey.

During the reconnaissance survey, several criteria are evaluated to determine if the site requires a detailed survey. These criteria include whether the site has a natural stream with a *definable* channel, if the active channel width (ACW) is 2 feet or greater, and if the channel gradient is less than 20 %. Natural streams are considered to support anadromous fish if they have an ACW of 2 ft and more than less than a 20% gradient.
Sites are also screened for potential constraints to fish passage. This assessment is currently restricted to bridges, as defined by Caltrans in the Caltrans Bridge Log (http://www.dot.ca.gov/hq/structur/strmaint/brlog2.htm). Criteria include**:**

- Natural versus hard bottom,
- Maintain freeboard during 100 year flow event,
- Hydraulic width compared to ACW,
- Orientation to stream ,
- Concentrated flow, and
- Gradient under, upstream and downstream of structure.

The specific criteria are discussed below.

General issues and questions commonly encountered during field survey

Sites to Omit

Structures that are clearly functioning as drainage facilities to pass storm water off of or around road surfaces are not to be identified or surveyed. Such facilities include road surface inlets and pipe drop inlets, described below. A more detailed description of these types of facilities and a Glossary of terms associated with s is provided in Appendices B and C.

- Road Surface Inlet. This type of inlet includes curb-openings, grate openings, or a combination that collects storm water off of the road surface into a drainage system.
- Pipe Drop Inlet. This inlet is located outside of the roadbed to capture runoff from small drainages upstream of the road or from roadside ditches or gutters.

A good rule of thumb for sites to survey is, if there is a pipe sticking out of the downstream side of the highway then survey the site. Also, if the surveyors spend more than 10 minutes assessing a potential site to verify its type, the location and screening level survey should be completed. This is done to provide back up information if anyone questions why culverts are not being assessed.

Culverts that cannot be found

When Caltrans culvert logs, geography, or paddle markers indicate that a culvert exists at a certain location, but it cannot be found, the potential culvert will be noted on the Caltrans culvert log. The location and screening information section of the survey form will be filled out to the extent possible, including a GPS location obtained at the approximate location of the culvert and other available location information. The reason that the culvert could not be found should be included as comments.

Culvert where a GPS reading is unobtainable

GPS data may not be attainable as some sites due to poor satellite coverage, vegetation, or other blockage of satellite signals. For those sites, make a note on the Caltrans culvert log and in the location and screening portion of the survey form then complete the entire survey.

Assessment of Bridges

Structures measuring more than 20 ft along the roadway centerline are conventionally classified as bridges, assigned a bridge number, and maintained and inspected by the Caltrans Division of Structures. However, some structures classified as bridges are designed hydraulically and structurally as culverts. Some examples are certain multi-barreled box culverts and arch culverts (see Appendices B and C). The location and screening level of the reconnaissance survey will be completed for ALL bridges, as indicated on Caltrans bridge logs. If it is labeled as a bridge and has a hard bottom or other potential obstruction to fish passage, treat it as a culvert and conduct a full fish passage assessment by completing the entire survey form

Part B. Reconnaissance Fish Passage Assessment Data Collection and Recording Instructions and Procedures

This section describes the data collection and recording procedures used to complete the reconnaissance assessment as defined by the reconnaissance survey form (Appendix C). The information is intended to be directly entered into an Access database using an electronic data sheet that has the same appearance as the forms in Appendix D. These forms can also be printed and used to record data if an electronic form is unavailable.

Header/Site Identification Information

The Header contains information specifically identifying the site using the County, Route and post mile.

County. Enter the name of the County where the survey site is located.
Route. Enter the highway or route number where the survey site is located.
Postmile. If a postmile paddle marker does not exist immediately near the survey site, the following methods should be used to estimate postmile:

Look for the nearest postmile indicator:
- Use Caltrans' postmile log for a listing of all major features (bridges, intersections, on/off ramps, etc.) along the roadway in sequential order by county, by mile
- Light standards ("street lights") are frequently marked and generally are at off- and on-ramps.
- Traffic signals on smaller highways through towns and cities may also be marked.
- Over- and underpasses

Estimate the distance from the known postmile indicator:
- Vehicle's trip odometer (reset the trip-meter at a known postmile marker, record interim postmile, and then travel to the next culvert location)
- If safe to do so and the length of your pace is known, pace off the distance along the highway shoulder; 0.01 mile is approximately 20 paces
- GPS (take a point at the known postmile, get a reading at the culvert location; GPS calculates the distance between points)
- Use a rangefinder

1.0 Survey Information

1.1 Date and Time

Enter the date
Enter the start and stop time.

1.2 Agency (or entity).

Enter the name of the agency, company or group performing the survey.

1.3 Data Recorder.

Enter the name of the person recording the data

1.4 Survey Team.

Enter the name of the person(s) collecting the survey data.

2.0 Site Information

2.1 GPS Data

A GPS point reading should be collected in the following order of priority: 1) at the top of the road prism at the break-in-slope immediately above the center line of the culvert inlet (midspan at upstream edge if a bridge), 2) at the break in slope immediately over the centerline of the culvert outlet (midspan at downstream edge if a bridge), or if the GPS point reading cannot be taken above the inlet or outlet (due to poor reception, lack of access, etc.), take the reading at 3) the nearest postmile marker (Paddle). Only one GPS point is needed per site. If multiple culverts are present, take point measurement at the culvert closest to the center of the crossing.

2.1.1 Latitude

Enter the latitude reading from the GPS receiver in numerical format to the nearest 0.000001. If the precision is less than to the nearest $10^{-6,}$ enter the reading and note precision in next section.

2.1.2 Longitude

Enter the longitude reading from the GPS receiver in numerical format to the nearest 0.000001. If the precision is less than to the nearest 10^{-6}, enter the reading and note precision in next section.

2.1.3 GPS HDOP

Enter the HDOP (precision for horizontal data) as displayed on the GPS unit

2.1.4 Location of GPS point

Indicate the location of the GPS reading by checking the appropriate box.

- Above inlet indicates the reading was taken while standing on the upstream shoulder over the center line of the inlet(s)
- Above outlet indicates the reading was taken while standing on the downstream shoulder over the center line of the outlet(s)
- If no access to either shoulder, take the GPS reading at the closest post mile marker and indicate the post mile on the datasheet.

2.2 Natural Stream Channel

This section is used to determine whether the channel is a naturally formed stream or a man-made waterway. The determination is based on presence of an obvious, definable channel, the channel's apparent function, or whether the waterway is identified as a stream on USGS maps or

similar references. A natural stream channel can have improvements and still meet the intent of this section. Only sites on natural stream channels are considered for detailed surveys.

2.2.1 Stream Name

Enter the stream name

2.2.2 Source

Enter the source that is used to determine the stream name (e.g., bridge sign, USGS map, etc.)

2.2.3 Definable channel

A definable channel is one that was naturally formed. It may display the attributes of a natural waterway or be improved. A man-mad ditch, canal or similar conveyance is not considered a definable channel.

2.2.4 Function

Determination of the channel function may assist in determining whether the channel is natural, improved or man-made. Indicate yes in the appropriate box if the channel is clearly a man-made structure designed for storm water management. A "yes" indicates that the site does not require a detailed survey and Item 4.1 should be completed accordingly.

2.2.5 Concrete Lining

Presence of a concrete-lined channel at the site suggests that the channel is man-made. However, improvements that include lining the three sides of the channel do not eliminate the site as a natural stream. This item is primarily informational and may influence how a detailed survey is approached.

The length of lined channel is an estimate and can be described as less than 100 ft, 100-1,000 ft or greater than 1,000 ft, as appropriate.

If either item 2.2.3 is marked "No" or item 2.2.4 is marked "Yes", the site is not a natural stream channel and no detailed survey is needed.

2.3 Fish Bearing Stream

The ability of the stream reach upstream of the site to support anadromous fish is characterized as a function of active channel width and channel slope. For purposes of this survey, a very narrow ACW or very steep gradients is considered to preclude use by anadromous fish.

Active channel width (ACW). Is the ACW) greater than 2 feet?

> *An active channel, as used in this protocol, is a waterway of perceptible extent that periodically or continuously contains moving water. It has definite bed and banks which serve to confine the water and includes stream channels, secondary channels, and braided channels. It is often determined by the "ordinary high water mark" which means that line on the shore established by the fluctuations of water and indicated by physical*

> *characteristics such as clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas* (NOAA 2001).

Visually estimate the ACW and answer "Yes" if the estimate is 2 ft or more. This is to screen small drainages that typically are not large enough to support anadromous fish.

Stream gradient less than 20%. Is the stream upstream gradient upstream of the crossing less than 20%?

Visually estimate the channel slope upstream of the crossing. If the slope is estimated to be less than 20 ft in 100 ft answer YES. This is to screen drainages that have natural topography that typically is too steep for fish to manage.

If either of these two conditions exists upstream of the site, a "No" is recorded in the appropriate row and there is no need for a detailed survey. Mark a "No" in the appropriate column of item 4.1.

2.4 Historic Anadromous Reach

This information should be obtained prior to visiting the site. Sources include the Caltrans Survey Prioritization Report, the Passage assessment database (PAD), NOAA distribution maps, the Coho Recovery Plan, and local authorities. A list of useful references is provided in Appendix E.

Mark this item "No" if the stream is known to have **never** supported anadromous salmonid fish populations.

If this item is marked "No", the Detailed Fish Passage Assessment survey is NOT required and the "No" column should be marked for item 4.1.

2.5 Crossing type.

(Select one)

> **Culvert.** A culvert is a conduit, pipe-like structure that typically passes through an embankment.
>
> The Caltrans Culvert log should be used to obtain a culvert ID.
>
> **Bridge.** A bridge is an open structures that spans 20 feet or more *often* with a natural bottom. Some bridges have numerous bays or even culverts. For example, if culverts are closely spaced (distance between culverts is less than the radius (or half the interior span) of the culvert and the structure spans 20 ft or more, it is defined as a bridge. All others need to be assessed as culverts.

The Caltrans bridge log should be used to obtain the Bridge ID and the bridge type.

Other (Comment). If other than a culvert or a bridge (e.g., ford), describe the type of stream crossing in the comment field.

If the site is a bridge, the following criteria should be assessed to determine if fish passage constraints exist or No detailed survey is required.

- The ACW is greater than the inlet width,
- The freeboard during a 100-year flow event is less than 10% of the bay height'
- The slope of the substrate beneath the structure is greater than 3%,
- The channel bottom is hardened versus a natural substrate,
- The orientation of the structure to the channel is greater than $45^{o,}$
- There is evidence of flow concentration (e.g., multi piers creating narrow bay openings or major cross section elevation differences)

Fish passage constraints may exist if the answer to any of the above criteria is YES.

If the bridge is determined to be free of fish passage constraints, indicate that No detailed survey is required by marking the No column of item 4.1.

3.0 Photos Taken

All four photographs described on the data sheet should be taken if a detailed survey is required. Only photo 3.3, taken from downstream looking upstream, needs to be taken for sites that will not require a detailed survey.

Note that the nomenclature for the photographs should include the county, route, PM, picture number (3.1, 3.2….) and the date.

4.0 Detailed Fish Passage Assessment survey requirement

4.1 Detailed Fish Passage Assessment required?

The appropriate column should be marked YES if information collected above did not result in the direction to mark No – NO DETAILED SURVEY REQUIRED-.

The following information only needs to be collected if a Detailed Fish Passage Assessment Survey IS required.

5.0 Access Information

A Detailed Fish Passage Assessment survey requires a right of entry as well as physical accessibility to the stream channel and the crossing facility. Information on ownership of lands adjacent to the Caltrans right of way at the site can often be determined as private or public while on site. Specific ownership may also be determined. Similarly, any constraints to physically accessing the site, such as fences, heavy vegetation, etc. needs to identified and resolved prior to conducting the Detailed Fish Passage Assessment survey.

5.1 Land Ownership

Land ownership needs to be assessed both upstream and downstream of the site. Ownership information should include whether the land is private or publicly owned. Any information such as signs that identify the land ownership should also be recorded.

5.2 Accessible from Road?

As much as 300 ft of channel, both up and downstream of the crossing may be accessed during the Detailed Fish Passage Assessment survey. Access should be identified as being possible (Yes), or not possible (No). If No, a description of the limiting conditions is required.

5.3 Vegetation Removal Required?

Dense vegetative cover can impede or prevent access to the channel and facility. This survey item is used to describe vegetation conditions that require removal, by Caltrans maintenance, before a Detailed Fish Passage Assessment survey can be conducted. Photographs of problem sites are required to aid Caltrans in determining how best to provide access and if other considerations, such as streambed alteration permits are necessary.

5.3.1 Upstream?

Is there a need to remove vegetation to access areas upstream of the site?

If YES, a brief description of the problem and a photograph are needed.

5.3.2 Downstream?

Is there a need to remove vegetation to access areas downstream of the site?

If YES, a brief description of the problem and a photograph are needed.

5.4 Maintenance Assistance Required

Constraints to access other than vegetation also need to be described for areas upstream and downstream of the site. These constraints could include traffic control.

5.4.1 Upstream?

Is there a need for maintenance to assist in providing access to areas upstream of the site?

If YES, a brief description of the problem and a photograph are needed.

5.4.2 Downstream?

Is there a need for maintenance to assist in providing access to areas downstream of the site?

If YES, a brief description of the problem and a photograph are needed.

6.0 Confined Space

The following three questions must be answered to determine if the culvert is considered a confined space. If so, special equipment and trained staff are needed to conduct a detailed survey.

6.1 Culvert diameter

Culvert diameter >60". Is the culvert greater than 5 feet high?

6.2 Visibility through culvert

See Daylight through Culvert. Can you see daylight through the culvert?

6.3 Breeze through culvert

Breeze through Culvert. Can you feel a breeze through the culvert?

Appendix A
List of Reconnaissance Assessment Survey Equipment and Supplies

APPENDIX A: List of Reconnaissance Assessment Survey Equipment and Supplies

Safety Equipment

- ☐ Hard Hat
- ☐ Safety Vest
- ☐ Emergency Contacts list (hospitals)
- ☐ Safety Manual
- ☐ PFD's (Personal Flotation Devices) in duffel
- ☐ Rotating safety light for vehicle
- ☐ Fire Extinguisher

Personal Safety Equipment

- ☐ Hat
- ☐ Work Boots with grips
- ☐ Chest Waders
- ☐ Rain gear
- ☐ Drinking Water
- ☐ Sunglasses
- ☐ Gloves
- ☐ Cell Phone, battery, car charger
- ☐ Sunscreen and Insect repellant
- ☐ Snacks/meals

Field Equipment

- ☐ Backpack
- ☐ DC/AC converter
- ☐ Portable printer
- ☐ Black Marking Pens, Pencils/Pens
- ☐ Flashlight
- ☐ Clip Board w/graph paper
- ☐ Two way radios & spare batteries
- ☐ Maps
- ☐ Machete/Loppers
- ☐ Tape (masking, scotch, duct)
- ☐ Binoculars (optional)
- ☐ Laptop computer w/ electronic data form
- ☐ GPS w/ charger
- ☐ Camera w/ charger
- ☐ First Aid Kit
- ☐ TechNu
- ☐ Clippers
- ☐ Copy of Task Order
- ☐ Caltrans culvert & bridge logs
- ☐ USGS Quad maps of route
- ☐ Clinometer (optional)
- ☐ Spare batteries

Other Personal & Miscellaneous Items

- ☐ Lava Soap (poison oak prevention)
- ☐ Large plastic bag (poison oaky clothes)
- ☐ Hand wipes/waterless sanitizer
- ☐ Ice chest, food & drink

Note:
Crew members are expected to report to work reasonably dressed to protect themselves during routine assignments and from exposure to usual and/or predictable physical and environmental conditions found at the work site.

Appendix B
Highway Drainage Terminology

Appendix B: Highway Drainage Terminology

The purpose of this section is to clarify highway drainage terms for the purpose of providing consistent terminology for drainage features and common understanding of sites to include in the Caltrans Fish Passage Culvert Assessment. This section borrows heavily from the Caltrans Highway Design Manual and US DOT Federal Highway Administration Hydraulic Design Series Number 5, Hydraulic Design of Highway Culverts.

Roadway Drainage

Roadway drainage involves the collection, conveyance, removal, and disposal of surface water runoff from the traveled way, shoulders, and adjoining roadside areas. Roadway drainage is also concerned with the handling of water from the following additional sources:

- Surface water from outside the right of way and not confined to channels that would reach the traveled way if not intercepted.
- Crossroads or streets.
- Irrigation of landscaped areas.

Standard highway drainage features include:

- Roadside ditches
- Dikes and gutters.
- Overside drains.
- Curbs and gutters.
- Storm drains.
- Drop inlets.

Ditches and Gutters

Slope Ditches.

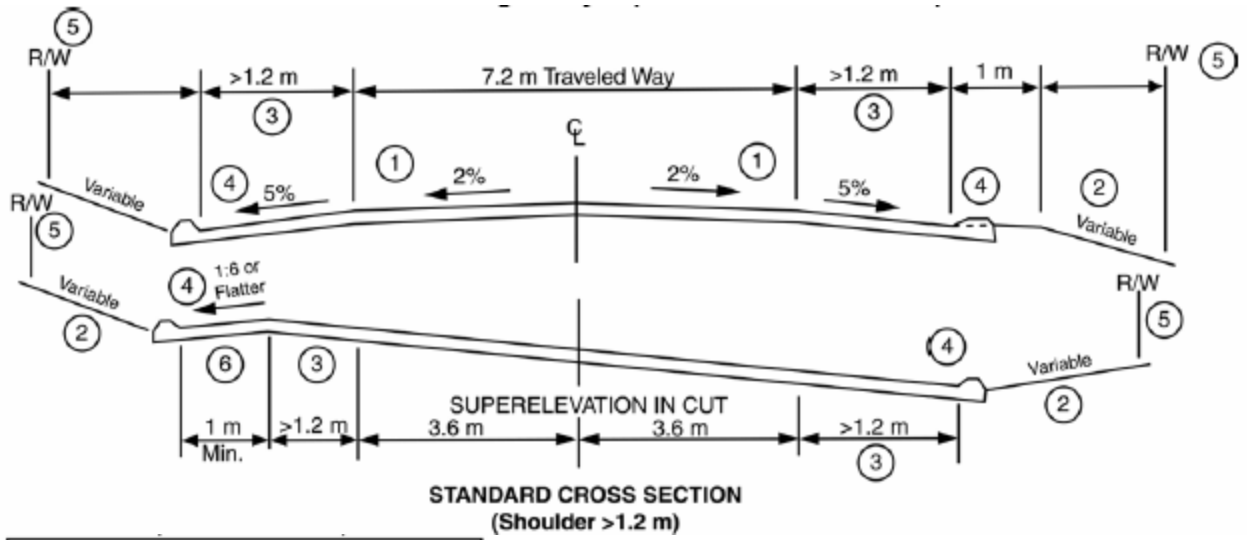
Slope ditches, sometimes called surface, brow, interception, or slope protection ditches, should be provided at the tops of cuts (parallel to the roadway) where it is necessary to intercept drainage from natural slopes inclined toward the highway.

Side Gutters.

These are triangular gutters adjoining the shoulder as shown below. The main purpose of the one meter wide side gutter is to prevent runoff from the cut slopes on the high side of super-elevation from flowing across the roadbeds.

Dikes.

Dikes placed adjoining the shoulder, as shown below provide a paved triangular gutter within the shoulder area.

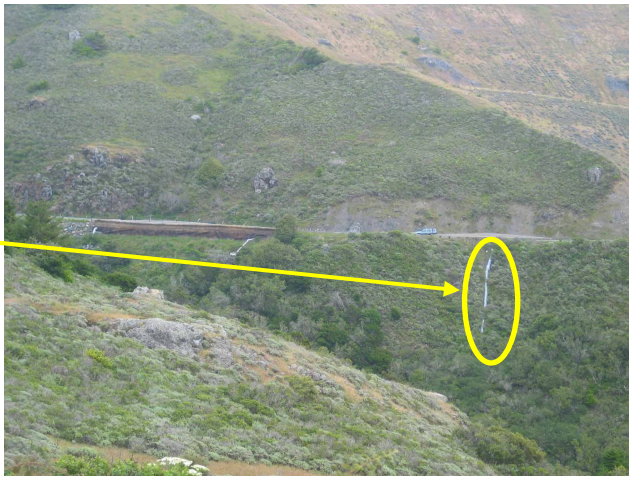


STANDARD CROSS SECTION
(Shoulder >1.2 m)

NOTES	
1 CROSS SLOPES	See Index 302.2
2 SIDE SLOPES	See Index 304.1
3 SHOULDER WIDTH	See Index 302.1
4 DIKES	See Index 835.3
5 RIGHT OF WAY	See Index 306.1
6 SIDE GUTTERS	See Index 834.3(3)

Overside Drains: The purpose of overside drains, sometimes called slope drains, is to protect slopes against erosion. They convey down the slope drainage which is collected from the roadbed, the tops of cuts, or from benches in cut or fill slopes. They may be pipes, flumes or paved spillways.

a) Pipe Downdrains. Metal and plastic pipes are adaptable to any slope. They should be used where side slopes are 1:4 or steeper.
b) Flume Downdrains. These are rectangular corrugated metal flumes with a tapered entrance.
c) Paved Spillways. Permanent paved spillways should only be used when the side slopes are flatter than 1:4.



Curbs and Gutters

The primary reason for constructing curbs and gutters may be for delineation or pedestrian traffic rather than for drainage considerations.

Storm Drains

The total drainage system which conveys runoff from roadway areas to a positive outlet including gutters, ditches, inlet structures, and pipe is generally referred to as a storm drain

system. In urban areas a highway storm drain often augments an existing or proposed local drainage plan and should be compatible with the local storm drain system.

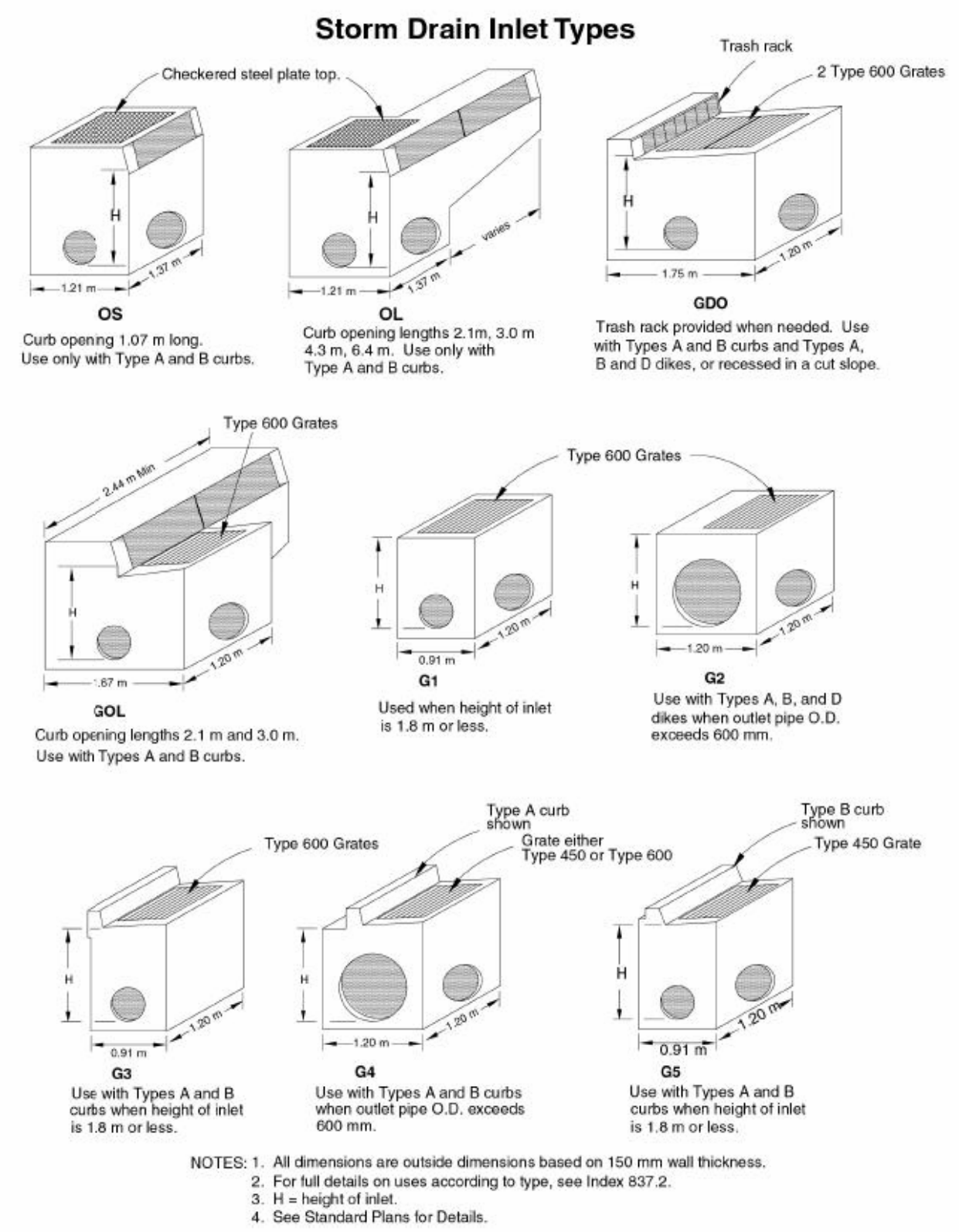
Storm Drain Inlet Types

1) Curb-Opening. Curb opening inlets have an opening parallel to the direction of flow in the gutter. This inlet group is adapted to curb and gutter installations. (type OS; OL)
2) Grate. Grate inlets provide a grate opening in the gutter or waterway. As a class, grate inlets perform satisfactorily over a wide range of gutter grades. Their main disadvantage is that they are easily clogged by floating trash and should not be used without a curb opening where total interception of flow is required. They merit preference over the curb opening (type G1-G5; GT1-GT4)

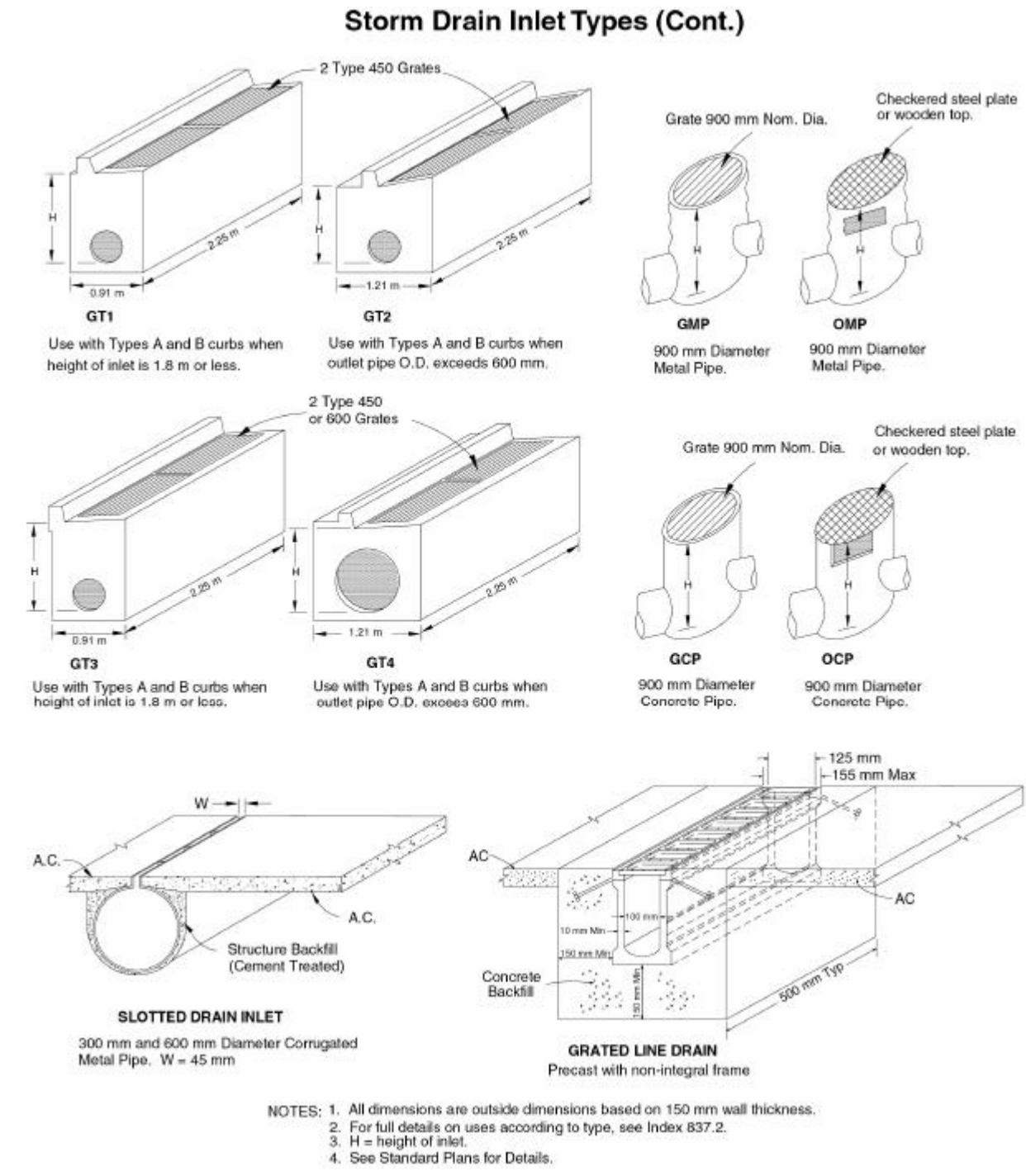
3) Combination. Combination inlets provide both a curb opening and a grate. (type GO; GDO; GOL)
4) Pipe. Pipe drop inlets are made of a commercial pipe section of concrete or corrugated metal. As a class, they develop a high capacity and are generally the most economical type. This type of inlet is intended for uses outside the roadbed at locations that will not be subjected to normal highway wheel loads.
   a) Wall Opening Intake. The opening in the side of the pipe is placed normal to the direction of surface flow. It develops a high capacity unaffected by the grade of the approach. (type OMP; OCP)
   b) Grate Intake. The grated top intercepts water from any direction. (type GMP; GCP)

5) Slotted Drains. This type of inlet is made of corrugated metal pipe with a continuous slot on top. The slot is formed by a pair of angle irons or grating which serves as a paving bulkhead. This type of inlet can be used in flush, all paved medians with super-elevated sections.
6) Grated Line Drains. This type of inlet is made of monolithic polymer concrete with a ductile iron frame and grate on top. This type of inlet can be used as an alternative at the

locations described under slotted drains, preferably in shoulder areas away from traffic loading.



NOTES: 1. All dimensions are outside dimensions based on 150 mm wall thickness.
2. For full details on uses according to type, see Index 837.2.
3. H = height of inlet.
4. See Standard Plans for Details.



CROSS DRAINAGE

Cross drainage involves the conveyance of surface water and stream flow across or from the highway right of way. This is accomplished by providing either a culvert or a bridge to convey

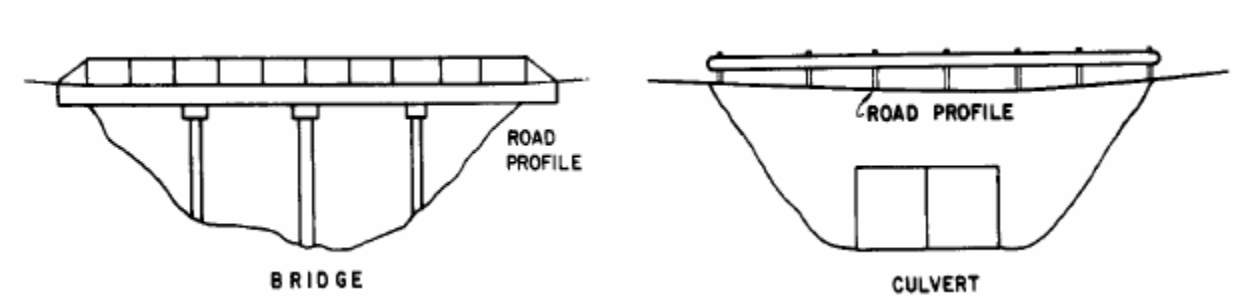
the flow from one side of the roadway to the other side or past some other type of flow obstruction.

Bridges:
Structures measuring more than 6.1 m along the roadway centerline are conventionally classified as bridges, assigned a bridge number, and maintained and inspected by the Division of Structures. However, some structures classified as bridges are designed hydraulically and structurally as culverts. Some examples are certain multi-barreled box culverts and arch culverts.

Culverts:
A culvert is a closed, hydraulically short conduit which conveys stream flow under a highway through a roadway embankment or past some other type of flow obstruction. Culverts are constructed from a variety of materials and are available in many different shapes and configurations.

Culverts, as distinguished from bridges, are usually covered with embankment and have structural material around the entire perimeter, although some are supported on spread footings with the streambed serving as the bottom of the culvert. The following three conditions constitute a culvert;

1. Single Barrel - span measured along centerline of road 6.1 m or less.
2. Multi-Barrels - total of the individual spans measured along centerline of road is 6.1 m or less.
3. Multi-Barrels - total of the individual spans measured along centerline of road is 6.1 m or greater, but the distance between individual culverts is more than one-half the culvert diameter.

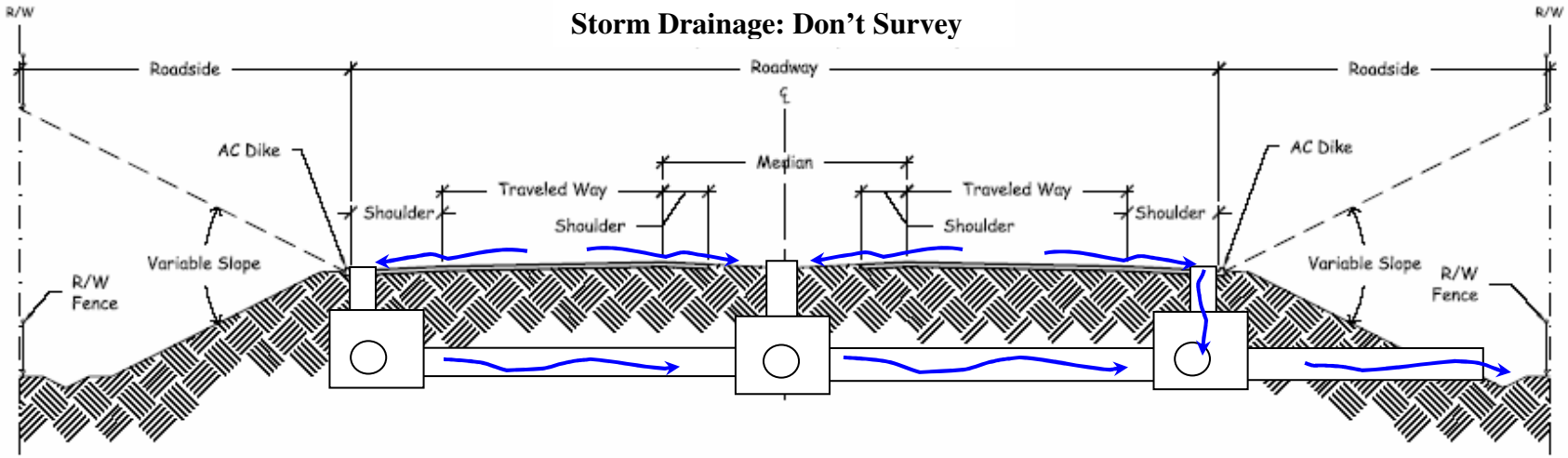


The culvert usually should be located so that the thalweg of the stream to be accommodated, approaches and exits at the approximate centerline of the culvert. Since the culvert typically acts as a constriction, local velocities will increase through the barrel and in the vicinity of the outlet. The location and design must be also sensitive to the environment (fish passage etc).
As a general rule, flood waters should be conducted under the highway at first opportunity minimizing scour of embankment and entrapment of debris. Therefore, culverts should be placed at each defined swale to limit carryover of drainage from one watershed to another.

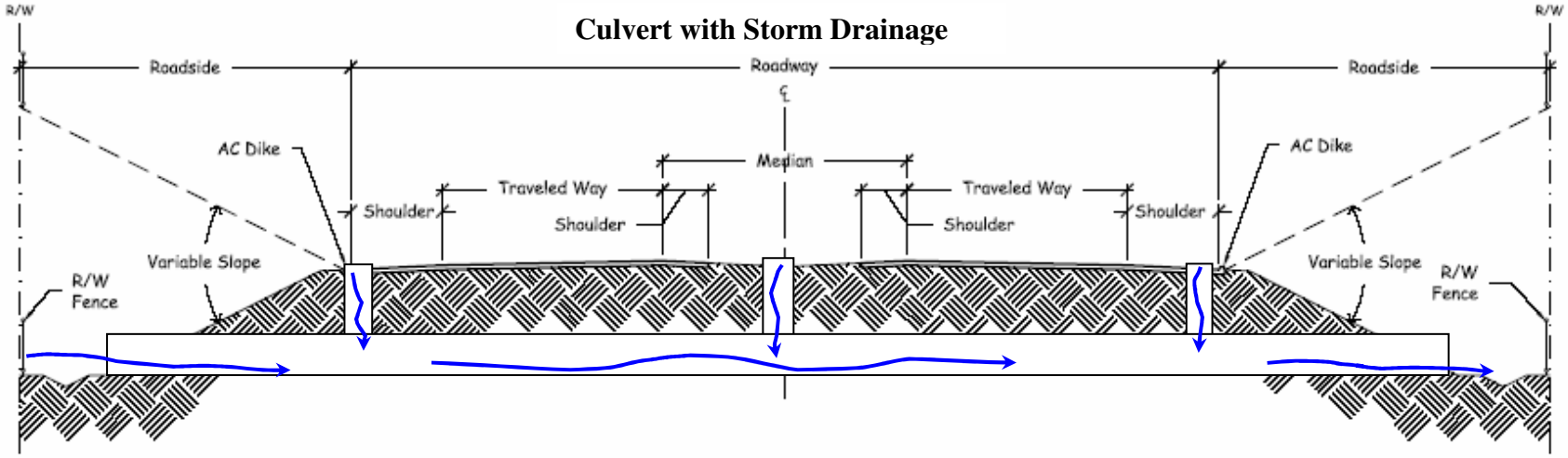
Alignment and Slope
The ideal culvert placement is on straight alignment and constant slope. Variations from a straight alignment should be only to accommodate unusual conditions. Ordinarily the grade line should coincide with the existing streambed. Deviations from this practice are permissible under the following conditions:

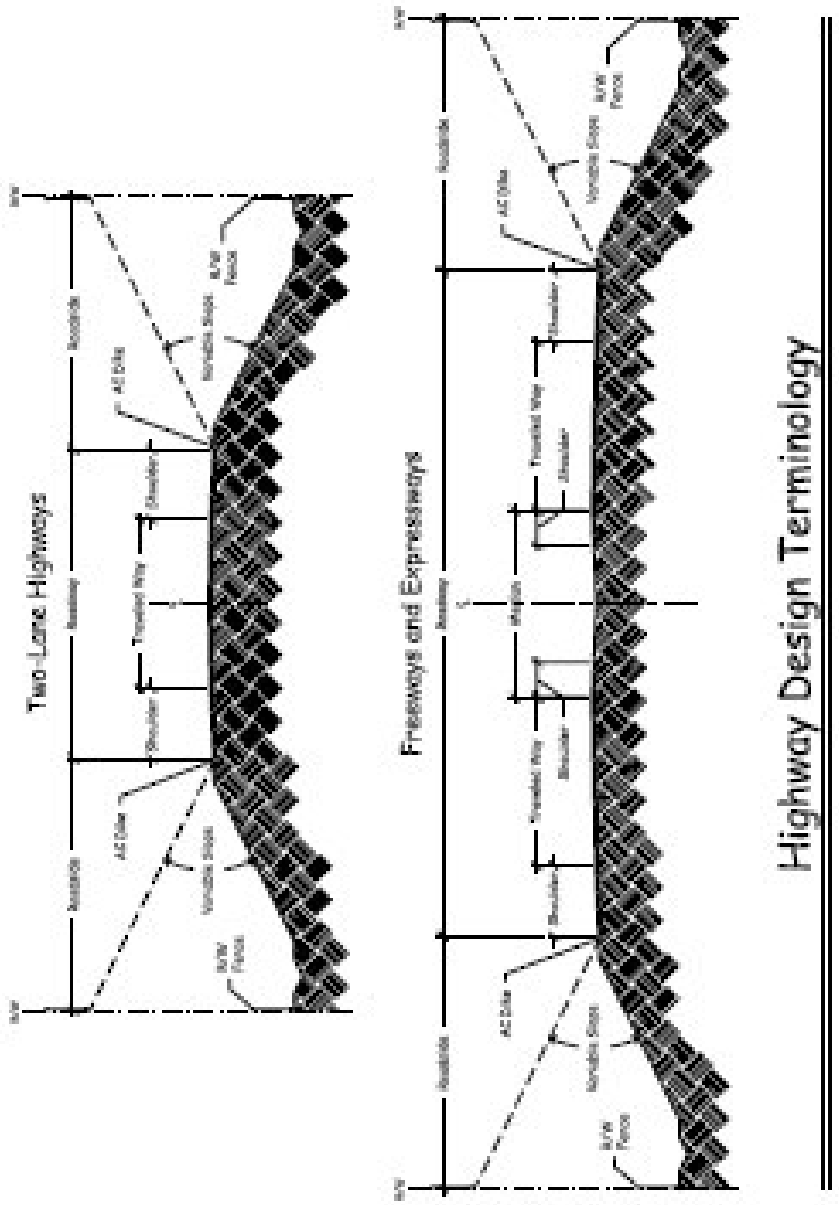
(a) On flat grades where sedimentation may occur, place the culvert inlet and outlet above the streambed but on the same slope. The distance above the streambed depends on the size length and amount of sediment anticipated. If possible, a slope should be used that is sufficient to develop self-cleaning velocities.
(b) Under high fills, anticipate greater settlement under the center than the sides of the fill.
(c) In steep sloping areas such as on hillsides, the overfill heights can be reduced by designing the culvert on a slope flatter than natural slope. However, a slope should be used to maintain a velocity sufficient to carry the bedload. A spillway or downdrain can be provided at the outlet. Outlet protection should be provided to prevent undermining. For the downdrain type of installation, consideration must be given to anchorage. This design is appropriate only where substantial savings will be realized.

Storm Drainage: Don't Survey



Culvert with Storm Drainage





Right of Way Diagram

Appendix C
Glossary of Applicable Hydraulic and Waterway Terms

Appendix C: Glossary of Applicable Hydraulic and Waterway Terms

Accretion. Outward growth of bank or shore by sedimentation. Increase or extension of boundaries of land by action of natural forces.

Action. Any highway construction, reconstruction, rehabilitation, repair, or improvement.

Active Channel Stage: The active channel or ordinary high water level is an elevation delineating the highest water level that has been maintained for a sufficient period of time to leave evidence on the landscape, such as the point where the natural vegetation changes from predominantly aquatic to predominantly terrestrial or the bank elevation at which the cleanly scoured substrate of the stream ends and terrestrial vegetation begins (Figure IX-3 and IX-4).

• A break in rooted vegetation or moss growth on rocks along stream margins

• Natural line impressed on the bank

• Shelving or terracing

• Changes in soil character

• Presence of deposited organic debris and litter

• Natural vegetation changes from predominantly aquatic to predominantly terrestrial.

An active channel discharge is less than a bankfull channel discharge.

Aggressive. Refers to the corrosive properties of soil and water.

Alluvial. Referring to deposits of silts, sands, gravels and similar detrital material which have been transported by running water.

Alluvium. Stream-borne materials deposited in and along a channel.

Anadromous Fish: Fish that migrate from the ocean into freshwater to breed. Includes salmon and steelhead, as well as several other species of fish.

Apron: A hardened surface (usually concrete or grouted riprap) placed at either the invert of the culvert inlet or outlet to protect structure from scour and storm damage. Aprons often are migration barriers because flow is often shallow with high velocities. Aprons at outlet may also create turbulence and increase stream power that often down cuts the channel, resulting in perched outlets and/or de-stabilized stream banks.

Aqueduct. (1) A major conduit. (2) The entire transmission main for a municipal water supply which may consist of a succession of canals, pipes, tunnels, etc. (3) Any conduit for water; especially one for a large quantity of flowing water. (4) A structure for conveying a canal over a river or hollow.

Aquifer. Water-bearing geologic formations that permit the movement of ground water.

Artesian Waters. Percolating waters confined below impermeable formations with sufficient pressure to spring or well up to the surface.

Avulsion. (1) A forcible separation; also, a part torn off. (2) The sudden removal of land from the estate of one man to that of another, as by a sudden change in a river, the property thus separated continuing in the original owner. (3) A sudden shift in location of channel.

Backwater. An unnaturally high stage in stream caused by obstruction or confinement of flow, as by a dam, a bridge, or a levee. Its measure is the excess of unnatural over natural stage, not the difference in stage upstream and downstream from its cause.

Baffles: Wood, concrete or metal panels mounted in a series on the floor and/or wall of a culvert to increase boundary roughness and thereby reduce the average water velocity in the culvert.

Bank. The lateral boundary of a stream confining water flow. The bank on the left side of a channel looking downstream is called the left bank, etc.

Bankfull Stage: Corresponds to the stage at which channel maintenance is most effective, that is, the discharge at which the stream is moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels. The bankfull stage is most effective or is the dominate channel-forming flow, and has a recurrence interval of 1.5 years (Dunne & Leopold 1978) (Figures IX-3 and IX-4).

Bank Protection. Revetment, or other armor protecting a bank of a stream from erosion, includes devices used to deflect the forces of erosion away from the bank.

Base Flood. The flood or tide having a 1 percent chance of being exceeded in any given year (100-year flood). The "base flood" is commonly used as the "standard flood" in Federal flood insurance studies. (see Regulatory Flood).

Base Floodplain. The area subject to flooding by the base flood.

Bedding. The foundation under a drainage structure.

Bed Load. Sediment that moves by rolling, sliding, or skipping along the bed and is essentially in contact with the stream bed.

Bedload: Sand, silt, and gravel, or soil and rock debris rolled along the bottom of a stream by the moving water. The particles of this material have a density or grain size which prevents movement far above or for a long distance out of contact with the streambed under natural flow conditions.

Bottomless-arch: A type of culvert with rounded sides and top attached to concrete or steel footings set below stream grade. The natural stream channel and substrate run through the length of the culvert, providing streambed conditions similar to the actual stream channel.

Braided Stream. A stream in which flow is divided at normal stage by small islands. This type of stream has the aspect of a single large channel with which there are subordinate channels.

Breaks-in-slope: Steeper sections within a culvert. As culverts age they often sag when road fills slump. *FishXing* is able to model changes in velocity created by varying slopes within several culvert sections.

Bulking. The increase in volume of flow due to air entrainment, debris, bedload, or sediment in suspension.

Camber. An upward adjustment of the profile of a drainage facility under a heavy loading (usually a high embankment) and poor soil conditions, so that as the drainage facility settles it approaches the design profile.

Capacity. The effective carrying ability of a drainage structure. Generally measured in cubic meters per second.

Capillarity. The attraction between water and soil particles which cause water to move in any direction through the soil mass regardless of gravitational forces.

Capillary Water. Water which clings to soil particles by capillary action. It is normally associated with fine sand, silt, or clay, but not normally with coarse sand and gravel.

Catch Basin. A drainage structure which collects water. May be either a structure where water enters from the side or through a grating.

CFS: Cubic feet per second.

Check Dam. A small dam generally placed in steep ditches for the purpose of reducing the velocity in the ditch.

Cienega. A swamp formed by water rising to the surface at a fault.

Cleanout. An access opening to a roadway drainage system. Usually consists of a manhole shaft, a special chamber or opening into a shallow culvert or drain.

Coefficient of Runoff. Percentage of gross rainfall which appears as runoff.

Composite Hydrograph. A plot of mean daily discharges for a number of years of record on a single year time base for the purpose of showing the occurrence of high and low flows.

Concentrated Flow. Flowing water that has been accumulated into a single fairly narrow stream.

Concentration. In addition to its general sense, means the unnatural collection or convergence of waters so as to discharge in a narrower width, and at greater depth or velocity.

Conduit. Any pipe, arch, box or drain tile through which water is conveyed.

Confluence. A junction of streams.

Contraction. The reduction in cross sectional area of flow.

Control. A section or reach of an open conduit or stream channel which maintains a stable relationship between stage and discharge.

Conveyance. A measure of the water carrying capacity of a stream or channel.

Corrugations: Refers to the undulations present in CSP and SSP culvert material. Corrugations provide surface roughness which increases over the width and depth of standard dimensions.

Cradle. A concrete base generally constructed to fit the shape of a structure which is to be forced through earthen material by a jacking operation. The cradle is constructed to line and grade. Then the pipe rides on the cradle as it is worked through the given material by jacking and tunneling methods. Also serves as bedding for pipes in trenches in special conditions.

Critical Depth. (Depth at which specific energy is a minimum) - The depth of water in a conduit at which under certain other conditions the maximum flow will occur. These other conditions are the conduit is on the critical slope with the water flowing at its critical velocity and there is an adequate supply of water. The depth of water flowing in an open channel or a conduit partially filled, for which the velocity head equals one-half the hydraulic mean depth.

Critical Flow. That flow in open channels at which the energy content of the fluid is at a minimum. Also, that flow which has a Froude number of one.

Critical Slope. That slope at which the maximum flow will occur at the minimum velocity. The slope or grade that is exactly equal to the loss of head per meter resulting from flow at a depth that will give uniform flow at critical depth; the slope of a conduit which will produce critical flow.

Critical Velocity. Mean velocity of flow when flow is at critical depth.

CSP: Corrugated steel pipe. Pipe diameter is comprised of a single sheet of material.

Culvert. A closed conduit which allows water to pass under a highway. The following three conditions constitute a culvert;

1. Single Barrel - span measured along centerline of road 6.1 m or less.

2. Multi-Barrels - total of the individual spans measured along centerline of road is 6.1 m or less.

3. Multi-Barrels - total of the individual spans measured along centerline of road is 6.1 m or greater, but the distance between individual culverts is more than one-half the culvert diameter.

Culvert: A specific type of stream crossing, used generally to convey water flow through the road prism base. Typically constructed of either steel, aluminum, plastic, or concrete. Shapes

include circular, oval, squashed-pipe (flat floor), bottomless-arch, square, or rectangular (Figure IX-10).

Culvert Entrance: The downstream end of a culvert through which a fish enter to pass upstream.

Culvert Exit: The upstream end of a culvert through which a fish exit to pass upstream.

Culvert Inlet: The upstream end of a culvert through which stream flow enters.

Culvert Outlet: The downstream end of a culvert through which stream flow discharges.

Current Meter. An instrument for measuring the velocity of a current. It is usually operated by a wheel equipped with vanes or cups which is rotated by the action of the impinging current. An indicating or recording device is provided to indicate the speed of rotation which is correlated with the velocity of the current.

Cutoff Wall. A wall at the end of a drainage structure, the top of which is an integral part of the drainage structure. This wall is usually buried and its function is to prevent undermining of the drainage structure if the natural material at the outlet of the structure is dug out by the water discharging from the end of the structure. Cutoff walls are sometimes used at the upstream end of a structure when there is a possibility of erosion at this point.

Debris. Any material including floating woody materials and other trash, suspended sediment, or bed load moved by a flowing stream.

Debris Barrier. A deflector placed at the entrance of a culvert upstream, which tends to deflect heavy floating debris or boulders away from the culvert entrance during high-velocity flow.

Debris Basin. Any area upstream from a drainage structure utilized for the purpose of retaining debris in order to prevent clogging of drainage structures downstream.

Debris Rack. A straight barrier placed across the stream channel which tends to separate light and medium floating debris from stream flow and prevent the debris from reaching the culvert entrance.

Degradation. General and progressive lowering of the longitudinal profile of a channel by erosion.

Design Discharge. The quantity of flow that is expected at a certain point as a result of a design storm. Usually expressed as a rate of flow in cubic meters per second.

Design Flood. The peak discharge (when appropriate, the volume, stage, or wave crest elevation) of the flood associated with the probability of exceedance selected for the design of a highway encroachment. By definition, the highway will not be inundated by the design flood.

Design Frequency. The recurrence interval for hydrologic events used for design purposes. As an example, a design frequency of 50 years means a storm of a magnitude that would be expected to recur on the average of every 50 years. (See Probability of Exceedance.)

Design Storm. That particular storm which contributes runoff which the drainage facilities were designed to handle. This storm is selected for design on the basis of its probability of exceedance or average recurrence interval (See Probability of Exceedance.)

Detention Storage. Surface water moving over the land is in detention storage. Surface water allowed to temporarily accumulate in ponds, basins, reservoirs or other types of holding facility and which is ultimately returned to a watercourse or other drainage system as runoff is in detention storage. (See Retention Storage)

Detritus. Loose material such as; rock, sand, silt, and organic particles.

Dike. Usually an earthen bank alongside and parallel with a river or open channel or an AC dike along the edge of a shoulder. (See Levee)

Dike, Finger. Relatively short embankments constructed normal to a larger embankment, such as an approach fill to a bridge. Their purpose is to impede flow and direct it away from the major embankment.

Dike, Spur. Relatively short embankments constructed at the upstream side of a bridge end for the purpose of aligning flow with the waterway opening and to move scour away from the bridge abutment.

Dike, Toe. Embankment constructed to prevent lateral flow from scouring the corner of the downstream side of an abutment embankment. Sometimes referred to as training dikes.

Dike, Training. Embankments constructed to provide a transition from the natural stream channel or floodplain, both to and from a constricting bridge crossing.

Discharge. A volume of water flowing out of a drainage structure or facility. Measured in cubic meters per second.

Diversion. The change in character, location, direction, or quantity of flow of a natural drainage course. A deflection of flood water is not diversion.

D-Load (Cracking D-Load). A term used in expressing the strength of concrete pipe. The cracking D-load represents the test load required to produce a 0.3 mm crack for a length of 300 mm.

Downdrain. A prefabricated drainage facility assembled and installed in the field for the purpose of transporting water down steep slopes.

Drainage. (1) The process of removing surplus ground or surface water by artificial means. (2) The system by which the waters of an area are removed. (3) The area from which waters are drained; a drainage basin.

Drainage Area (Drainage Basin) (Basin). That portion of the earth's surface upon which falling precipitation flows to a given location. With respect to a highway, this location may be either a culvert, the farthest point of a channel, or an inlet to a roadway drainage system.

Drainage Course. Any path along which water flows when acted upon by gravitational forces.

Drainage Divide. The rim of a drainage basin. A series of high points from which water flows in two directions, to the basin and away from the basin.

Drainage Easement (See Easement).

Drainage System. Usually a system of underground conduits and collector structures which flow to a single point of discharge.

Drawdown. The difference in elevation between the water surface elevation at a constriction in a stream or conduit and the elevation that would exist if the constriction were absent. Drawdown also occurs at changes from mild to steep channel slopes and weirs or vertical spillways.

Dry Weather Flows. A small amount of water which flows almost continually due to lawn watering, irrigation or springs.

Dune. A sand wave of approximately triangular cross section (in a vertical plane in the direction of flow) formed by moving water or wind, with gentle upstream slope and steep downstream slope and deposition on the downstream slope.

Easement. Right to use the land of others.

Eddy Loss. The energy lost (converted into heat) by swirls, eddies, and impact, as distinguished from friction loss.

Embedment: The depth to which a culvert bottom is buried into the streambed. It is usually expressed as a percentage of the culvert height or diameter.

Encroachment. Extending beyond the original or customary limits, such as by occupancy of the river and/or flood plain by earth fill embankment.

Endwall. A wall placed at the end of a culvert. It may serve three purposes; one, to hold the embankment away from the pipe and prevent sloughing into the pipe outlet channel; two, to provide a wall which will prevent erosion of the roadway fill; and three, to prevent flotation of the pipe.

Energy Dissipater. A structure for the purpose of slowing the flow of water and reducing the erosive forces present in any rapidly flowing body of water.

Energy Grade Line. The line which represents the total energy gradient along the channel. It is established by adding together the potential energy expressed as the water surface elevation referenced to a datum and the kinetic energy (usually expressed as velocity head) at points along the stream bed or channel floor.

Energy Head. The elevation of the hydraulic grade line at any section plus the velocity head of the mean velocity of the water in that section.

Entrance Head. The head required to cause flow into a conduit or other structure; it includes both entrance loss and velocity head.

Entrance Loss. The head lost in eddies and friction at the inlet to a conduit or structure.

Equalizer. A drainage structure similar to a culvert but different in that it is not intended to pass a design flow in a given direction. Instead it is often placed level so as to permit passage of water in either direction. It is used where there is no place for the water to go. Its purpose is to maintain the same water surface elevation on both sides of the highway embankment.

Erosion. The wearing away of a surface by some external force. In the case of drainage terminology, this term generally refers to the wearing away of the earth's surface by flowing water. It can also refer to the wear on a structural surface by flowing water and the material carried therein.

Erosion and *Scour*. The cutting or wearing away by the forces of water of the banks and bed of a channel in horizontal and vertical directions, respectively.

Erosion and *Accretion*. Loss and gain of land, respectively, by the gradual action of a stream in shifting its channel by cutting one bank while it builds on the opposite bank. Property is lost by erosion and gained by accretion but not by *avulsion* when the shift from one channel to another is sudden. Property is gained by *reliction* when a lake recedes.

Estuary. That portion of a river channel occupied at times or in part by both sea and river flow in appreciable quantities. The water usually has brackish characteristics.

Evaporation. A process whereby water as a liquid is changed into water vapor, typically through heat supplied from the sun.

Exceedance Flow: N% exceedance flow is the flow that is equaled or exceeded n% of the time.

Fan. A portion of a cone, but sometimes used to emphasize definition of radial channels. Also reference to spreading out of water or soils associated with waters leaving a confined channel.

Fish Passage: The ability of both adult and juvenile fish to move both up and down stream.

Fishway: A structure for passing fish over vertical impediments. It may include special attraction devices, entrances, collection and transportation channels, a fish ladder and exit.

FishXing: A computer software program developed by the Six Rivers National Forest Watershed Interactions Team. *FishXing* models culvert hydraulics (including open-bottom structures) and compares the predicted values with data regarding swimming and leaping abilities and minimum water depth requirements for numerous fish species.

Fetch. The distance across open water through which wind acts to generate waves.

Flap Gate. This is a form of valve that is designed so that a minimum force is required to push it open but when a greater water pressure is present on the outside of the valve, it remains shut so as

to prevent water from flowing in the wrong direction. Construction is simple with a metal cover hanging from an overhead rod or pinion at the end of a culvert or drain.

Flood Frequency. Also referred to as exceedance interval, recurrence interval or return period; the average time interval between actual occurrences of a hydrological event of a given or greater magnitude; the percent chance of occurrence is the reciprocal of flood frequency, e.g., a 2 percent chance of occurrence is the reciprocal statement of a 50-year flood. (See Probability of Exceedance.)

Flood Frequency: The frequency with which a flood of a given discharge has the probability of recurring. For example, a "100-year" frequency flood refers to a flood discharge of a magnitude likely to occur on the average of once every 100 years or, more properly, has a one-percent chance of being exceeded in any year. Although calculation of possible recurrence is often based on historical records, there is no guarantee that a "100-year" flood will occur at all within the 100-year period or that it will not recur several times.

Floodplain: The area adjacent to the stream constructed by the river in the present climate and inundated during periods of high flow.

Floodplain. Normally dry land areas subject to periodic temporary inundation by stream flow or tidal overflow. Land formed by deposition of sediment by water; alluvial land.

Floodplain Encroachment. An action within the limits of the base flood plain.

Flood Plane. The position occupied by the water surface of a stream during a particular flood. Also, loosely, the elevation of the water surface at various points along the stream during a particular flood.

Flood Prone Zone: Spatially, this area generally corresponds to the modern floodplain, but can also include river terraces subject to significant bank erosion. For delineation, see definition for floodplain.

Floodproof. To design and construct individual buildings, facilities, and their sites to protect against structural failure, to keep water out or reduce the effects of water entry.

Flood Stage. The elevation at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured.

Flood Waters. Former stream waters which have escaped from a watercourse (and its overflow channel) and flow or stand over adjoining lands. They remain as such until they disappear from the surface by infiltration, evaporation, or return to a natural watercourse. They do not become surface waters by mingling with such waters, nor stream waters by eroding a temporary channel.

Flow. A term used to define the movement of water, silt, sand, etc.; discharge; total quantity carried by a stream.

Flow Duration (or Annual Exceedance Flow): A flow duration curve describes the natural flow characteristics of a stream by showing the percentage of time that a flow is equal to or greater than a given value during a specified period (annual, month, or migration period). Flow exceedance values are important for describing the flow conditions under which fish passage is required.

Flow Line. A term used to describe the line connecting the low points in a watercourse.

Flow Regime. The system or order characteristic of streamflow with respect to velocity, depth, and specific energy.

Freeboard. (1) The vertical distance between the level of the water surface usually corresponding to the design flow and a point of interest such as a bridge beam, levee top or specific location on the roadway grade. (2) The distance between the normal operating level and the top of the sides of an open conduit; the crest of a dam, etc., designed to allow for wave action, floating debris, or any other condition or emergency, without overtopping the structure.

Free Outlet. A condition under which water discharges with no interference such as a pipe discharging into open air.

Free Water. Water which can move through the soil by force of gravity.

French Drain. A trench loosely backfilled with stones, the largest stones being placed in the bottom with the size of stones decreasing towards the top. The interstices between the stones serve as a passageway for water.

Froude Number. A dimensionless expression of the ratio of inertia forces to gravity forces, used as an index to characterize the type of flow in a hydraulic structure in which gravity is the force producing motion and inertia is the resisting force. It is equal to a characteristic flow velocity (mean, surface, or maximum) of the system divided by the square root of the product of a characteristic dimension (as diameter of depth) and the gravity constant (acceleration due to gravity) all expressed in consistent units. Fr = V/(gy)1/2

Gaging Station. A location on a stream where measurements of stage or discharge are customarily made. The location includes a reach of channel through which the flow is uniform, a control downstream from this reach and usually a small building to house the recording instruments.

Grade to Drain. A construction note often inserted on a plan for the purpose of directing the Contractor to slope a certain area in a specific direction, so that the surface waters will flow to a designated location.

Gradient (Slope). The rate of ascent or descent expressed as a percent or as a decimal as determined by the ratio of the change in elevation to the length.

Gradient Control Weirs: Stabilizing weirs constructed in the streambed to prevent lowering of the channel bottom.

Gradually Varied Flow. In this type of flow, changes in depth and velocity take place slowly over large distances, resistance to flow dominates and acceleration forces are neglected.

Ground Water. That water which is present under the earth's surface. Ground water is that situated below the surface of the land, irrespective of its source and transient status. Subterranean streams are flows of ground waters parallel to and adjoining stream waters, and usually determined to be integral parts of the visible streams.

Head. Represents an available force equivalent to a certain depth of water. This is the motivating force in effecting the movement of water. The height of water above any point or plane of reference. Used also in various compound expressions, such as energy head, entrance head, friction head, static head, pressure head, lost head, etc.

Headcutting. Progressive scouring and degrading of a streambed at a relatively rapid rate in the upstream direction, usually characterized by one or a series of vertical falls.

Hydraulic Capacity: The maximum amount of flow (in cfs) that a stream crossing can convey at 100% of inlet height.

Hydraulic Controls: Weirs constructed primarily of rocks or logs, in the channel below a culvert for the purpose of controlling water depth and water velocity within the crossing.

Hydraulic Gradient. A line which represents the relative force available due to the potential energy available. This is a combination of energy due to the height of the water and the internal pressure. In any open channel, this line corresponds to the water surface. In a closed conduit, if several openings were placed along the top of the pipe and open tubes inserted, a line connecting the water surface in each of these tubes would represent the hydraulic grade line.

Hydraulic Jump (or Jump). Transition of flow from the rapid to the tranquil state. A varied flow phenomenon producing a rise in elevation of water surface. A sudden transition from supercritical flow to the complementary subcritical flow, conserving momentum and dissipating energy.

Hydraulic Jump: An abrupt transition in streamflow from shallow and fast (supercritical flow) to deep and slow (subcritical flow).

Hydraulic Mean Depth. The area of the flow cross section divided by the water surface width.

Hydraulic Radius. The cross sectional area of a stream of water divided by the length of that part of its periphery in contact with its containing conduit; the ratio of area to wetted perimeter.

Hydrograph. A graph showing stage, flow, velocity, or other property of water with respect to time.

Hydrography. Water Surveys. The art of measuring, recording, and analyzing the flow of water; and of measuring and mapping watercourses, shore lines, and navigable waters.

Hydrology. The science dealing with the occurrence and movement of water upon and beneath the land areas of the earth. Overlaps and includes portions of other sciences such as meteorology and geology. The particular branch of Hydrology that a design engineer is generally interested in is surface runoff which is the result of excessive precipitation.

Hyetograph. Graphical representation of rainfall intensity against time.

Incised Channel. Those channels which have been cut relatively deep into underlying formations by natural processes. Characteristics include relatively straight alignment and high, steep banks such that overflow rarely occurs, if ever.

Infiltration. The passage of water through the soil surface into the ground.

Inlet: Upstream entrance to a culvert.

Inlet Invert: Location at inlet, on the culvert floor where an elevation is measured to calculate culvert slope.

Inlet Time. The time required for storm runoff to flow from the most remote point, in flow time, of a drainage area to the point where it enters a drain or culvert.

Inlet Transition. A specially shaped entrance to a box or pipe culvert. It is shaped in such a manner that in passing from one flow condition to another, the minimum turbulence or interference with flow is permitted.

Inundate. To cover with a flood.

Invert: Lowest point of the crossing.

Invert. The bottom of a drainage facility along which the lowest flows would pass.

Invert Paving. Generally applies to metal pipes where it is desirable to improve flow characteristics or prevent corrosion at low flows. The bottom portion of the pipe is paved with an asphaltic material, concrete, or airblown mortar.

Inverted Siphon. A pipe for conducting water beneath a depressed place. A true inverted siphon is a culvert which has the middle portion at a lower elevation than either the inlet or the outlet and in which a vacuum is created at some point in the pipe. A sag culvert is similar, but the vacuum is not essential to its operation.

Isohyetal Line. A line drawn on a map or chart joining points that receive the same amount of precipitation.

Isohyetal Map. A map containing isohyetal lines and showing rainfall intensities.

Isovel. Line on a diagram of a channel connecting points of equal velocity.

Jack (or Jack Straw). Bank protection element consisting of wire or cable strung on three mutually perpendicular struts connected at their centers.

Jacking Operations. A means of constructing a pipeline under a highway without open excavation. A cutting edge is placed on the first section of pipe and the pipe is forced ahead by hydraulic jacks. As the leading edge pushes ahead, the material inside the pipe is dug out and transported outside the pipe for disposal.

Jetty. An elongated, artificial obstruction projecting into a stream or the sea from bank or shore to control shoaling and scour by deflection of strength of currents and waves.

Lag. Variously defined as time from beginning (or center of mass) of rainfall to peak (or center of mass) of runoff.

Laminar Flow. That type of flow in which each particle moves in a direction parallel to every other particle and in which the head loss is approximately proportional to the velocity (as opposed to turbulent flow).

Lateral. In a roadway drainage system, a drainage conduit transporting water from inlet points to the main drain trunk line.

Levee. An embankment to prevent inundation. (See Dike)

Local Depression. A low area in the pavement or in the gutter established for the special purpose of collecting surface waters on a street and directing these waters into a drainage inlet.

Maximum Average Water Velocity in Culvert: The highest average water velocity for any cross section along the length of the culvert, excluding the effects of water surface drawdown at the culvert outlet.

Maximum Historical Flood. The maximum flood that has been recorded or experienced at any particular highway location.

Mean Annual Flood. The flood discharge with a recurrence interval of 2.33 years.

Meander. In connection with streams, a winding channel usually in an erodible, alluvial valley. A reverse or S-shaped curve or series of curves formed by erosion of the concave bank, especially at the downstream end, characterized by curved flow and alternating shoals and bank erosions. Meandering is a stage in the migratory movement of the channel, as a whole, down the valley.

Meander Plug (Clay Plug). Deposits of cohesive materials in old channel bendways. These plugs are sufficiently resistant to erosion to serve as essentially semi-permanent geological controls to advancing channel migrations.

Meander Scroll. Evidence of historical meander patterns in the form of lines visible on the inside of meander bends (particularly on aerial photographs) which resemble a spiral or convoluted form in ornamental design. These lines are concentric and regular forms in high sinuosity channels and are largely absent in poorly developed braided channels.

Mud Flow. A well-mixed mass of water and alluvium which, because of its high viscosity, and low fluidity as compared with water, moves at a much slower rate, usually piling up and spreading out like a sheet of wet mortar or concrete.

Natural and Beneficial Floodplain Values. Includes but are not limited to fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and groundwater recharge.

Navigable Waters. Those stream waters lawfully declared or actually used as such. Navigable Waters of the State of California are those declared by Statute. Navigable Waters of the United States are those determined by the Corps of Engineers or the U.S. Coast Guard to be so used in interstate or international commerce. Other streams have been held navigable by courts under the common law that navigability in fact is navigability in law.

Negative Projecting Conduits. A structure installed in a trench with the top below the top of trench, then covered with backfill and embankment. See Positive Projecting Conduit

Nonuniform Flow. A flow in which the velocities vary from point to point along the stream or conduit, due to variations in cross section, slope, etc.

Normal Depth. The depth at which flow is steady and hydraulic characteristics are uniform.

Normal Water Surface (Natural Water Surface). The free surface associated with flow in natural streams.

"n" Value. The roughness coefficient in the Manning formula for determination of the discharge coefficient in the Chezy formula, $V = C(RS)^{1/2}$, where $C = \frac{1}{n}R^{1/6}$

Off-Site Drainage. The handling of that water which originates outside the highway right of way.

On-Site Drainage. The handling of that water which originates inside the highway right of way.

Open Channel. Any conveyance in which water flows with a free surface.

Ordinary High Water Mark. The line on the shore established by the fluctuation of water and physically indicated on the bank (1.5 + years return period)

Ordinary High Water Mark: The mark along the bank or shore up to which the presence and action of the water are common and usual, and so long continued in all ordinary years, as to leave a natural line impressed on the bank or shore and indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics.

Outfall. Discharge or point of discharge of a culvert or other closed conduit.

Outlet: Downstream opening of a culvert.

Outlet Invert: Location at outlet, on the culvert floor, where an elevation is measured to calculate culvert slope.

Outwash. Debris transported from a restricted channel to an unrestricted area where it is deposited to form an alluvial or debris cone or fan.

Overtopping Flood. The flood described by the probability of exceedance and water surface elevation at which flow occurs over the highway, over the watershed divide, or through structure(s) provided for emergency relief.

Passage Flow: Migration flows.

Peak Flow: One-hundred year flow event.

Peak Flow. Maximum momentary stage or discharge of a stream in flood. Design Discharge.

Perched Outlet: A condition in which a culvert outlet is suspended over the immediate downstream pool, requiring a migrating fish to leap into culvert.

Perched Water. Ground water located above the level of the water table and separated from it by a zone of impermeable material.

Percolating Waters. Waters which have infiltrated the surface of the land and move slowly downward and outward through devious channels (aquifers) unrelated to stream waters, until they reach an underground lake or regain and spring from the land surface at a lower point.

Permeability. The property of soils which permits the passage of any fluid. Permeability depends on grain size, void ratio, shape and arrangement of pores.

Physiographic Region. A geographic area whose pattern of landforms differ significantly from that of adjacent regions.

Pipe-arch: A type of culvert with a flat floor and rounded sides and top, usually created by shaping or squashing a circular CSP or SSP pipe.

Piping. The action of water passing through or under an embankment and carrying some of the finer material with it to the surface at the downstream face.

Point of Concentration. That point at which the water flowing from a given drainage area concentrates. With reference to a highway, this would generally be either a culvert entrance or some point in a roadway drainage system.

Poised Stream. A term used by river engineers applying to a stream that over a period of time is neither degrading or aggrading its channel, and is nearly in equilibrium as to sediment transport and supply.

Positive Projecting Conduit. A structure installed in shallow trench with the top of the conduit projecting above the top of the trench and then covered with embankment. See Negative Projecting Conduit.

Potamology. The hydrology of streams.

Practicable. Capable of being done within reasonable natural, social, and economic constraints.

Precipitation. Rainfall, snow, sleet, fog, hail, dew and frost.

Prescriptive Rights. The operation of the law whereby rights may be established by long exercise of their corresponding powers or extinguished by prolonged failure to exercise such powers.

Preserve. To avoid modification to the functions of the natural floodplain environment or to maintain it, as closely as practicable, in its natural state.

Probability of Exceedance. The statistical probability, expressed as a percentage, of a hydrologic event occurring or being exceeded in any given year. The probability (p) of a storm or flood is the reciprocal of the average recurrence interval (N).

Probable Maximum Flood. The flood discharge that may be expected from the most severe combination of critical meteorological and hydrological conditions that are reasonably possible in the region.

Pumping Plant. A complete pumping installation including a storage box, pump or pumps, standby pumps, connecting pipes, electrical equipment, pumphouse and outlet chamber.

Rainfall. Point Precipitation: That which registers at a single gauge. Area Precipitation: Adjusted point rainfall for area size.

Q_{hp}: Stream discharge (in cfs) at high passage flow. For adult salmonids, in California defined as the 1% exceedance flow (the flow equaled or exceeded 1% of the time) during the period of expected migration.

Q_{lp}: Stream discharge (in cfs) at low passage flow. For adult salmonids, in California defined as the 90% exceedance flow for the migration period.

Rainwash. The creep of soil lubricated by rain.

Rapidly Varied Flow. In this type of flow, changes in depth and velocity take place over short distances, acceleration forces dominate, and energy loss due to friction is minor.

Reach. The length of a channel uniform with respect to discharge, depth, area, and slope. More generally, any length of a river or drainage course.

Recurrence Interval: Also referred to as flood frequency, or return period. It is the average time interval between actual occurrences of a hydrological event of a given or greater magnitude. A flood event with a two-year recurrence interval has a 50% chance of occurring in any given year.

Regime. The system or order characteristic of a stream; its behavior with respect to velocity and volume, form of and changes in channel, capacity to transport sediment, amount of material supplied for transportation, etc.

Regimen. The characteristic behavior of a stream during ordinary cycles of flow.

Regulatory Floodway. The open floodplain area that is reserved in by Federal, State, or local requirements, i.e., unconfined or unobstructed either horizontally or vertically, to provide for the discharge of the base flood so that the cumulative increase in water surface elevation is no more than a designated amount (not to exceed 0.3048 m as established by the Federal Emergency Management Agency (FEMA) for administering the National Flood Insurance Program (NFIP)).

Reliction. Pertaining to being left behind. For example: that area of land is left behind by reliction when the water surface of a lake is lowered.

Restore. To reestablish a setting or environment in which the functions of the natural and beneficial floodplain values adversely impacted by the highway agency can continue to operate.

Retarding Basin. Either a natural or man made basin with the specific function of delaying the flow of water from one point to another. This tends to increase the time that it takes all the water falling on the extremities of the drainage basin to reach a common point, resulting in a reduced peak flow at that point.

Retention Storage. Water which accumulates and ponds in natural or excavated depressions in the soil surface with no possibility for escape as runoff. (See Detention Storage)

Retrogression. Reversal of stream grading; i.e., aggradation after degradation, or vice versa.

Revetment. Bank protection to prevent erosion.

Riffle Crest: See "tailwater control".

Riparian. Pertaining to the banks of a stream.

Riprap. Protection against erosion consisting of broken concrete, sacked concrete, rock, etc.

Ripple. (1) The light fretting or ruffling of a water caused by a breeze. (2) Undulating ridges and furrows, or crests and troughs formed by action of the flow.

Risk. The consequences associated with the probability of flooding attributable to an encroachment. It includes the potential for property loss and hazard to life during the service life of the highway.

Risk Analysis. An economic comparison of design alternatives using expected total costs (construction costs plus risk costs) to determine the alternative with the least expected cost to the public. It must include probable flood-related costs during the service life of the facility for highway operation, maintenance, and repair, for highway aggravated flood damage to other property, and for additional or interrupted highway travel.

Riser. In mountainous terrain where much debris is encountered, the entrance to a culvert sometimes becomes easily clogged. Therefore, a corrugated metal pipe or a structure made of timber or concrete with small perforations, called a riser, is installed vertically to permit entry of water and prohibit the entry of mud and debris. The riser may be increased in height as the need occurs.

Roads: For purposes of these guidelines, roads include all sites of intentional surface disturbance for the purpose of vehicular or rail traffic and equipment use, including all surfaced and unsurfaced roads, temporary roads, closed and inoperable roads, legacy roads, skid trails, tractor roads, layouts, landings, turnouts, seasonal roads, fire lines, and staging areas.

Rounded Inlet. The edges of a culvert entrance that are rounded for smooth transition which reduces turbulence and increases capacity.

Runoff. The portion of precipitation that appears as flow in streams. Drainage or flood discharge which leaves an area as surface flow or a pipeline flow, having reached a channel or pipeline by either surface or subsurface routes.

Sag Culvert (or Sag Pipe). A pipeline with a dip in its grade line crossing over a depression or under a highway, railroad, canal, etc. The term inverted siphon is common but inappropriate as no siphonic action is involved. The term "sag pipe" is suggested as a substitute.

Salmonids: A taxonomic group of fish that includes salmon and steelhead, among others.

Scour. The result of erosive action of running water, primarily in streams, excavating and carrying away material from the bed and banks. Wearing away by abrasive action.

Scour, General. The removal of material from the bed and banks across all or most of the width of a channel, as a result of a flow contraction which causes increased velocities and bed shear stress.

Scour, Local. Removal of material from the channel bed or banks which is restricted to a minor part of the width of a channel. This scour occurs around piers and embankments and is caused by the actions of vortex systems induced by the obstruction to the flow.

Scour, Natural. Removal of material from the channel bed or banks which occurs in streams with the migration of bed forms, shifting of the thalweg and at bends and natural contractions.

Section 10 and 404 Regulatory Programs: The principal federal regulatory programs, carried out by the US Army Corps of Engineers, affecting structures and other work below mean high water. The Corps, under Section 10 of the River and Harbor Act of 1899, regulates structures in, or affecting, navigable waters of the US as well as excavation or deposition of materials (e.g., dredging or filling) in navigable waters. Under Section 404 of the Federal Water Pollution Control Act Amendments (Clean Water Act of 1977), the Corps is also responsible for evaluating application for Department of the Army permits for any activities that involve the placement of dredged or fill material into waters of the United States, including adjacent wetlands.

Sediment. Fragmentary material that originates from weathering of rocks and is transported by, suspended in, or deposited by water.

Sedimentation. Gravitational deposit of transported material in flowing or standing water.

Seismic Wave. A gravity wave caused by an earthquake.

Sheet Flow. Any flow spread out and not confined; i.e., flow across a flat open field.

Shoaling. Deposition of alluvial material resulting in areas with relatively shallow depth.

Significant Encroachment. A highway encroachment and any direct support of likely base floodplain development that would involve one or more of the following construction or flood related impacts:

- A significant potential for interruption or termination of a transportation facility which is needed for emergency vehicles or provides a community's only evacuation route.
- A significant risk, or
- A significant adverse impact on natural and beneficial floodplain values.

Silt. (1) *Water-Borne Sediment.* Detritus carried in suspension or deposited by flowing water, ranging in diameter from 0.005 to 0.05 mm. The term is generally confined to fine earth, sand, or mud, but is sometimes both suspended and bedload. (2) *Deposits of Water-Borne Material.* As in a reservoir, on a delta, or on floodplains.

Sinuosity. The ratio of the length of the river thalweg to the length of the valley proper.

Skew. When a drainage structure is not normal (perpendicular) to the longitudinal axis of the highway, it is said to be on a skew. The skew angle is the smallest angle between the perpendicular and the axis of the structure.

Slide. Gravitational movement of an unstable mass of earth from its natural position.

Slipout. Gravitational movement of an unstable mass of earth from its constructed position. Applied to embankments and other man-made earthworks.

Slope. (1) Gradient of a stream. (2) Inclination of the face of an embankment, expressed as the ratio of horizontal to vertical projection; or (3) The face of an inclined embankment or cut slope. In hydraulics it is expressed as percent or in decimal form.

Slough. (1) Pronounced SLU. A side or overflow channel in which water is continually present. It is stagnant or slack; also a waterway in a tidal marsh. (2) Pronounced SLUFF. Slide or slipout of a thin mantle of earth, especially in a series of small movements.

Slugflow. Flow in culvert or drainage structure which alternates between full and partly full. Pulsating flow -- mixed water and air.

Soffit. The bottom of the top -- (1) With reference to a bridge, the low point on the underside of the suspended portion of the structure. (2) In a culvert, the uppermost point on the inside of the structure.

Specific Energy. The energy contained in a stream of water, expressed in terms of head, referred to the bed of a stream. It is equal to the mean depth of water plus the velocity head of the mean velocity.

SSP: Structural steel plate. Pipe diameter is comprised of multiple sheets of material which are usually bolted together.

Stage. The elevation of a water surface above its minimum; also above or below an established "low water" plane; hence above or below any datum of reference; gage height.

Standing Wave. A term which when used to describe the upper flow regime in alluvial channels, means a vertical oscillation of the water surface between fixed nodes without appreciable progression in either an upstream or downstream direction. To maintain the fixed position, the wave must have a celerity (velocity) equal to the approach velocity in the channel, but in the opposite direction.

Steady Flow. A flow in which the flow rate or quantity of fluid passing a given point per unit of time remains constant.

Storage. Detention, or retention of water for future flow, naturally in channel and marginal soils or artificially in reservoirs.

Storage Basin. Space for detention or retention of water for future flow, naturally in channel and marginal soils, or artificially in reservoirs.

Storm. A disturbance of the ordinary, average conditions of the atmosphere which, unless specifically qualified, may include any or all meteorological disturbances, such as wind, rain, snow, hail, or thunder.

Storm Drain. That portion of a drainage system expressly for collecting and conveying former surface water in an enclosed conduit. Often referred to as a "storm sewer", storm drains include inlet structures, conduit, junctions, manholes, outfalls and other appurtenances.

Storm Water Management. The recognition of adverse drainage resulting from altered runoff and the solutions resulting from the cooperative efforts of public agencies and the private sector to mitigate, abate, or reverse those adverse results.

Stream Crossing: Any human-made structure generally used for transportation purposes that crosses over or through a stream channel including: a paved road, unpaved road, railroad track, biking or hiking trail, golf-cart path, or low-water ford. A stream crossing encompasses the structure employed to pass stream flow as well as associated fill material within the crossing prism.

Stream Power. An expression used in predicting bed forms and hence bed load transport in alluvial channels. It is the product of the mean velocity, the specific weight of the water sediment mixture, the normal depth of flow and the slope.

Stream Response. Changes in the dynamic equilibrium of a stream by any one, or combination of various causes.

Stream Waters. Former surface waters which have entered and now flow in a well defined natural watercourse, together with other waters reaching the stream by direct precipitation or rising from springs in bed or banks of the watercourse. They continue as stream waters as long as they flow in the watercourse, including overflow and multiple channels as well as the ordinary or low-water channel.

Strutting. Elongation of the vertical axis of pipe prior to installing in a trench. After the backfill has been placed around the pipe and compacted, the wires or rods holding the pipe in its distorted shape are removed. Greater side support from the earth is developed when the pipe tends to return to its original shape. Generally used on pipes which because of size or thinness of the metal would tend to deform during construction operations. Arches are strutted diagonally per standard or special plan.

Subcritical Flow. In this state, gravity forces are dominant, so that the flow has a low velocity and is often described as tranquil and streaming. Also, that flow which has a Froude number less than one.

Subdrain. A conduit for collecting and disposing of underground water. It generally consists of a pipe, with perforations in the bottom through which water can enter.

Sump. In drainage, any low area which does not permit the escape of water by gravity flow.

Supercritical Flow. In this state, inertia forces are dominant, so that flow has a high velocity and is usually described as rapid, shooting and torrential. Also, that flow which has a Froude number greater than one.

Supercritical Flow: Fast and shallow flowing water that is usually associated with a hydraulically steep, smooth surface.

Support Base Floodplain Development. To encourage, allow, serve, or otherwise facilitate additional base floodplain development. Direct support results from an encroachment, while indirect support results from an action out of the base floodplain.

Surface Runoff. The movement of water on earth's surface, whether flow is over surface of ground or in channels.

Surface Waters. Surface waters are those which have been precipitated on the land from the sky or forced to the surface in springs, and which have then spread over the surface of the ground without being collected into a definite body or channel. They appear as puddles, sheet or overland flow, and rills, and continue to be surface waters until they disappear from the surface by infiltration or evaporation, or until by overland or vagrant flow they reach well defined watercourses or standing bodies of water like lakes or seas.

Suspended Load. Sediment that is supported by the upward components of turbulent currents in a stream and that stay in suspension for appreciable amount of time.

Swale. A shallow, gentle depression in the earth's surface. This tends to collect the waters to some extent and is considered in a sense as a drainage course, although waters in a swale are not considered stream waters.

Tailwater Control: The channel feature which influences the water surface elevation immediately downstream of the culvert outlet. The location controlling the tailwater elevation is often located at the riffle crest immediately below the outlet pool. Tailwater control is also the channel elevation that determines residual pool depth.

Tapered Inlet. A transition to direct the flow of water into a channel or culvert. A smooth transition to increase hydraulic efficiency of an inlet structure.

Thalweg. The line following the lowest part of a valley, whether under water or not. Usually the line following the deepest part of the bed or channel of a river.

Thalweg: The line connecting the lowest or deepest points along a stream bed.

Time of Concentration. The time required for storm runoff to flow from the most remote point, in flow time, of a drainage area to the point under consideration. It is usually associated with the design storm.

Trash Rack. A grid or screen across a stream designed to catch floating debris.

Trunk (or Trunk Line). In a roadway drainage system, the main conduit for transporting the storm waters. This main line is generally quite deep in the ground so that laterals coming from fairly long distances can drain by gravity into the trunk line.

Tsunami. A gravity wave caused by an underwater seismic disturbance (such as sudden faulting, land sliding or volcanic activity).

Turbulence. A state of flow wherein the water is agitated by cross-currents and eddies, as opposed to a condition of flow that is quiet and laminar.

Turbulent Flow. That type of flow in which any particle may move in any direction with respect to any other particle, and in which the head loss is approximately proportional to the square of the velocity.

Undercut. Erosion of the low part of a steep bank so as to compromise stability of the upper part.

Underflow. The downstream flow of water through the permeable deposits that underlie a stream. (1) Movement of water through a pervious subsurface stratum, the flow of percolating water; or water under ice, or under a structure. (2) The rate of flow or discharge of subsurface water.

Unsteady Flow. A flow in which the velocity changes with respect to space and time.

Velocity Head. A term used in hydraulics to represent the kinetic energy of flowing water. This "head" is represented by a column of standing water equivalent in potential energy to the kinetic energy of the moving water calculated as ($V^2/2g$) where the "V" represents the velocity in meters per second and "g"

represents the potential acceleration due to gravity, in meters per second per second.

Watercourse. A definite channel with bed and banks within which water flows, either continuously or in season. A watercourse is continuous in the direction of flow and may extend laterally beyond the definite banks to include overflow channels contiguous to the ordinary channel. The term does not include artificial channels such as canals and drains, except natural channels trained or restrained by the works of man. Neither does it include depressions or swales through which surface or errant waters pass.

Waters of the United States: Currently defined by regulation to include all navigable and interstate waters, their tributaries and adjacent wetlands, as well as isolated wetlands and lakes and intermittent streams.

Watershed. The area drained by a stream or stream system.

Water Table. The surface of the groundwater below which the void spaces are completely saturated.

Waterway. That portion of a watercourse which is actually occupied by water.

Weephole. A hole in a wall, invert, apron, lining, or other solid structure to relieve the pressure of groundwater.

Weir. A low overflow dam or sill for measuring, diverting, or checking flow.

Weir: a) A notch or depression in a levee, dam, embankment, or other barrier across or bordering a stream, through which the flow of water is measured or regulated; b) A barrier constructed across a stream to divert fish into a trap; c) A dam (usually small) in a stream to raise the water level or divert its flow.

Appendix D
Reconnaissance Assessment Survey Form

D- RECONNAISSANCE ASSESSMENT SURVEY FORM

County _____
Route _____
PM _____

v. 033107

	YES	NO	UNK	QC
1.0 SURVEY INFORMATION				
1.1 Date: Time:	1.2 Agency performing survey			
1.3 Data recorder:	1.4 Survey team:			
2.0 SITE INFORMATION				
2.1 GPS Data				
2.1.1 Latitude:				
2.1.2 Longitude:				
2.1.3 GPS HDOP				
2.1.4 Location of GPS point taken: ☐ Above inlet ☐ Above outlet ☐ At postmile paddle marker (PM)				
2.2 Natural Stream Channel				
2.2.1 Stream Name:	2.2.2 Source:			
2.2.3 Is there a definable channel upstream of the crossing?				
If "No", indicate in section 4.1 that no Detailed Fish Passage Assessment is needed				
2.2.4 Is the primary function for storm water runoff or road drainage**?**				
If "Yes", indicate in section 4.1 that no Detailed Fish Passage Assessment is needed				
2.2.5 Is the waterway a concrete-lined flood control channel**?**				
If yes, indicate the extent of concrete lining: Upstream of crossing: _____ ft Downstream of crossing: _____ft				
If "Yes" is, Detailed Fish Passage Assessment needed?				
2.3 Fish Bearing Stream				
2.3.1 Does the site contain an active channel width >2 feet?				
2.3.2 Is the stream gradient < 20%?				
If "No" to either question, indicate in section 4.1 that no Detailed Fish Passage Assessment is needed.				
2.4 Historic Anadromous Reach:				
Has the stream reach upstream of the crossing supported an anadromous fish population?				
Source:				
If "No", indicate in section 4.1 that no Detailed Fish Passage Assessment is needed.				
2.5 Crossing Type:				
☐ Culvert ☐ Bridge w/ potential passage constraints ☐ Bridge w/o passage constraints ☐ Other				
General Description: ID:				
If crossing is "bridge w/o passage constraints", Indicate "NO" in section 4.1.				
3.0 Photos Taken				
3.1 Upstream looking upstream Photo ID				
3.2 Upstream looking downstream Photo ID				
3.3 Downstream looking upstream Photo ID (Required for all sites)				
3.4 Downstream looking downstream Photo ID				
4. Detailed Fish Passage Assessment Survey Requirement				
4.1 Detailed Fish Passage Assessment Required?				

5. ACCESS INFORMATION

(CONTINUE IF DETAILED FISH PASSAGE ASSESSMENT IS REQUIRED)

5.1 Land Ownership					
Upstream ☐ Public ☐ Private ☐ Unknown Owner(s)					
Downstream ☐ Public ☐ Private ☐ Unknown Owner(s)					
	YES	NO	UNK	QC	
5.2 Accessible from Road?					
5.2.1 Upstream? Limitations:					
5.2.2 Downstream? Limitations :					
5.3 Vegetation Removal Required?					
5.3.1 Upstream? (If yes comment and take photograph) Photo ID Comment:					
5.3.2 Downstream? (If yes comment and take photograph) Photo ID Comment:					
5.4 Maintenance Assistance Required?					
5.4.1 Upstream? (If yes comment and take photograph) Photo ID Comment:					
5.4.2 Downstream? (If yes comment and take photograph) Photo ID Comment:					

6. CONFINED SPACE ASSESSMENT

If answer is "No" to any of the following questions, site must have confined spaces equipment for surveying. DO NOT ENTER CULVERT

6.1 Is the culvert diameter > 60"?				
6.2 Can you see all the way through the end of the culvert?				
6.3 Can you feel a breeze through the culvert?				

Appendix E
California Coast Salmon and Steelhead Distribution References

APPENDIX E. California Coast salmon and steelhead distribution references

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